TRANSACTIONS

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(Vol. XXIV.—January, 1891.)

PROGRESS REPORT OF THE COMMITTEE ON STANDARD RAIL SECTIONS.*

To the President and Members of the American Society of Civil Engineers:

Your Committee on Standard Rail Sections begs leave to submit the following progress report:

The Committee met at the House of the Society, October 1st, eight members being present and four absent (one appointment being vacant); and organized by the choice of G. Bouscaren as Chairman, and A. M. Wellington as Secretary.

After some preliminary discussion it was resolved on motion of Mr. Morison that each member of the Committee be requested to propose a design, or scheme, for a set of sections, and transmit the same to the Secretary of the Committee on or before December 1st, 1890; and that the Secretary be requested to canvass these suggestions and report to the Committee in what respects they agree and disagree. It was also resolved that these sections be prepared according to the individual preference of each member, regardless of any prior recommendations.

In accordance with this resolution ten different sets of designs have been prepared and transmitted to the Secretary, submitted by eleven

* Presented and accepted at the Annual Meeting, January 21st, 1891.

different members, viz.: Messrs. G. Bouscaren, J. Foster Crowell, S. M. Felton, Jr., H. Stanley Goodwin and Samuel Rea, J. D. Hawks, R. W. Hunt, George S. Morison, E. D. T. Myers, Thomas Rodd and A. M. Wellington. V. G. Bogue was appointed on the Committee too late to prepare a set of sections, and no set has been received from Mr. F. M. Wilder, the only remaining member of the Committee.

The last of these sets of sections was not received until just before the meeting; consequently the Committee has not yet been able to take any action upon the report of the Secretary in regard to them. The Secretary's report is subjoined to this report, with engravings of the several sets of sections, and the accompanying memoranda sent in by the members of the Committee.

These sections show a fair degree of agreement, considering that they were designed prior to all attempt at comparison of views. The further steps of the Committee have not yet been determined on.

For the Committee.

G. Bouscaren,
Chairman.

Report of the Secretary to the Committee.

To the Committee on Standard Rail Sections:

Agreeably to the vote of instructions passed at the last meeting of the Committee, to the effect that each member of the Committee be requested to send to the Secretary of the Committee a set of sections embodying his own personal preferences or suggestions in regard to a set of Standard Sections, and that the Secretary report to the Committee in what respects they agree and disagree, the Secretary submits the following report:

Ten different complete sets of designs have been received, from eleven different members of the Committee, the only members who have not sent in sections being Messrs. Bogue and Wilder. Full-size drawings of these sections are shown on the accompanying sheet. Messrs. Rea and Goodwin submit a set of sections conjointly. The sections appear to show a remarkable degree of uniformity in their main features. In their several details they stand as follows:

1. The late Committee on the Proper Relation to Each Other of the Sections of Railway Wheels and Rails made the following recommendations: (1) 12-inch top radius; (2) $\frac{1}{4}$-inch corner radius; (3) vertical sides; (4) $\frac{1}{16}$-inch lower corner radius; (5) broad head relatively to depth. In regard to these details, the suggestions of the members of the present Committee stand as follows:

(1) 12-inch top radius. (2) $\frac{1}{4}$-inch corner radius. (3) Vertical sides.	9 sets of sections out of 10 agree with all these recommendations. The set by Messrs. Rea and Goodwin has $\frac{7}{16}$ to $\frac{1}{2}$ inch corner radius and slightly flaring sides, but retains the 12-inch top radius.

(4.) $\frac{1}{16}$ inch lower corner radius. All sections have this except that Messrs. Hunt, Rea and Goodwin make it $\frac{1}{8}$-inch. Bouscaren and Crowell $\frac{3}{32}$, Hawks a sharp corner (being 5 for $\frac{1}{16}$-inch, 5 for a somewhat larger radius, and 1 for a sharp corner).

(5) Broad head relatively to depth.—This recommendation being in-

determinate, the degree of agreement can best be judged from the sections. It appears to be unanimously accepted in principle, except that Mr. Morison sacrifices it to some extent to obtain the same width of head ($2\frac{1}{2}$ inches) for all sections from 50 to 100 pounds, inclusive. Messrs. Rea and Goodwin's sections are also a partial exception.

(6) Total Height.

The preferences as to this may be tabulated as follows:

Weight of Section.	Bouscaren.	Crowell.	Felton.	Goodwin and Rea.	Hawks.	Hunt.	Moris on	Myers.	Rodd.	Wellington.	Average.
Pounds.											
40	3.50	3.75	3.50	3.50	3.62	3.50	....	3.65	....	3.67	3.58
50	3.87	4.00	4.00	4.00	4.00	4.00	3.95	4.00	4.00	4.00	3.98
60	4.25	4.25	4.00	4.25	4.50	4.25	4.33	4.40	4.25	4.33	4.28
70	4.62	4.62	4.50	4.50	4.75	4.75	4.68	4.73	4.75	4.67	4.66
80	5.00	5.00	5.00	4.75	5.00	5.00	5.00	5.07	5 00	5.00	4.98
90	5.37	5.37	5.50	5.00	5.19	5.50	5.30	5.38	5.25	5.33	5.37
100	5.75	6.00	6.00	5.25	5.50	5.75	5.59	5.68	5.50	5.67	5.47
110	....	....	....	....	....	....	....	....	...	6.00	....

The sections sent in by Messrs. Morison, Myers and Wellington vary in height by some fixed law; all others determine heights arbitrarily. The effort seems to approximate to a uniform variation of $\frac{1}{3}$ inch in height for each 10 pounds per yard of difference in weight.

Width of Base.—The Goodwin and Rea set of sections has the base $\frac{1}{4}$ inch wider than the total height throughout. Otherwise the width of base is the same as the total height throughout the sections, with but two partial sections; Crowell makes the 100-pound section $5\frac{1}{2}$ inch base to 6 inches high; Mr. Wellington stops widening the base at 5 inches with the 80-pound section (to and including which the width and height are alike) and retains a 5-inch base for a 90, 100 and 110-pound section, with heights $5\frac{1}{3}$, $5\frac{2}{3}$ and 6 inches respectively. This is stated to be done for the reason that rails above 80 pounds demand the use of base-plates, for which a 5-inch base is sufficient, while for such heavy sections it becomes increasingly important to have sections well adapted for rolling.

Mean Distribution of Metal, Average of all Sections.

	Head per cent.	Neck per cent.	Base per cent.	Head Varies Between
Bouscaren	44.5	20.4	35.1	42.7 and 45.3 per cent.
Crowell	40.8	24.0	35.2	38.7 and 41.5 "
Felton	42.6	18.7	38.7	39.5 and 44.3 "
Goodwin-Rea	46.1	19.5	34.4	42.2 and 49.7 "
Hawks	40.6	22.5	36.9	36.6 and 42.9 "
Hunt	41.0	20.9	38.1	40.0 and 42.0 "
Morison	41.5	21.0	37.5	Ratio uniform.
Myers	43.2	20.7	36.1	40.6 and 44.0 "
Rudd	44.6	19.0	36.4	44.0 and 46.2 "
Wellington	40.0	22.5	37.5	Ratio uniform.
Average	42.79	20.92	36.59	

The apparent interest in all the sections, the set of Messrs. Rea and Goodwin excepted, was to distribute the metal to head, neck and base in a constant percentage for all sections. Messrs. Morison and Wellington do this explicitly, and Mr. Crowell announces this as a principle, though his sections do not exactly agree with it. Messrs. Bouscaren, Felton and Hawks show a tendency to slightly decrease the percentage in the head as the weight increases; Messrs. Goodwin and Rea, to increase the percentage in the head as the weight increases. All other sections (including practically nine of the ten sets), tend to a constant percentage regardless of weight, as shown in the following table, showing the percentage of metal in the head of each section. It has not appeared necessary to construct similar tables for the percentages in neck and base.

PERCENTAGE OF METAL IN HEAD FOR EACH SECTION.

Weight of Section.	40	50	60	70	80	90	100	Average
Bouscaren	44.8	(45.0)	45.3	(45.2)	45.0	(44.0)	42.7	44.5
Crowell	38.7	43.2	40.7	40.9	41.5	41.3	39.2	40.8
Felton	42.8	42.7	43.7	44.3	44.3	41.1	39.5	42.6
Goodwin-Rea	42.2	42.5	44.6	47.5	46.6	49.5	49.7	46.1
Hawks	42.9	40.8	40.3	40.5	41.9	40.9	36.6	40.6
Hunt	40.0	40.7	41.7	41.6	42.0	40.8	40.0	41.0
Morison	41.5	41.5	41.5	41.5	41.5	41.5	41.5	41.5
Myers	40.6	43.4	44.0	43.7	43.7	43.5	43.5	43.2
Rudd	44.0	44.0	45.7	43.3	44.4	46.2	44.7	44.6
Wellington	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Average	41.75	42.38	42.75	42.85	43.09	42.88	41.74	42.49

WIDTH OF HEAD.—The preferences as to this may be tabulated as follows:

Wt. of Section, lbs. per Yard.	Bouscaren.	Crowell.	Felton.	Goodwin and Rea.	Hawks.	Hunt.	Morison.	Myers.	Rodd.	Wellington.	Average.
40	1.87	2.00	2.12	1.78	1.87	1.87	....	1.82	....	2.12	1.94
50	2.06	2.12	2.25	2.12	2.06	2.06	2.50	2.00	2.19	2.25	2.16
60	2.25	2.25	2.37	2.28	2.19	2.19	"	2.20	2.31	2.37	2.29
70	2.37	2.34	2.50	2.47	2.31	2.56	"	2.37	2.37	2.50	2.43
80	2.50	2.50	2.62	2.55	2.50	2.62	"	2.53	2.50	2.62	2.54
90	2.62	2.72	2.75	2.75	2.75	"	"	2.69	2.56	2.75	2.67
100	2.75	2.87	2.87	2.86	"	"	"	2.84	2.81	2.87	2.78
110	....	....	....	....	....	....	....	....	....	(3.00)	
Total Range, 40 to 100 lbs.	0.87	0.87	0.75	1.08	0.87	0.75	none.	1.02	0.62	0.75	0.79

Messrs. Felton and Wellington submit uniformly varying widths of heads (varying by ⅛ inch, all others vary irregularly or (Morison's) not at all.

DEPTH OF HEAD.—This may be tabulated as follows:

Wt. of Section, lbs. per Yard.	Bouscaren.	Crowell.	Felton.	Goodwin and Rea.	Hawks.	Hunt.	Morison.	Myers.	Rodd.	Wellington.	Average.
40	1.06	1.12*	1.00	Not tabulated. See Sections.	1.00	0.98	....	1.12†	....	0.90*	1.02
50	....	1.19	1.12		1.12	1.12	1.01*	1.23†	1.19	1.04	1.12
60	1.33	1.25	1.25		1.25	1.28	1.17	1.35	1.37†	1.17*	1.27
70	....	1.44	1.37		1.37	1.39	1.34	1.45	1.47†	1.28*	1.39
80	1.58	1.50	1.50		1.50	1.50	1.50	1.56	1.62†	1.39*	1.51
90	....	1.56	1.56		1.50	1.56	1.66	1.65	1.81†	1.49*	1.60
100	1.70	1.62	1.62		1.50*	1.70	1.82†	1.74	1.78	1.58	1.70

* Minimum. † Maximum.

Angle of Base of Head and Top of Base.—All sections have these two angles alike. Messrs. Crowell, Felton and Rodd use 13 degrees; Messrs. Rea and Goodwin, 13½ degrees; Messrs. Hunt, Morison and Wellington, 1 in 4, or 14 degrees; Mr. Myers, 1 in 4½, or 12 degrees; Mr. Bouscaren, 12 degrees; and Mr. Hawks, 11 degrees.

Fillet Radius.—In every case but one this is the same at both top and bottom of the neck. Messrs. Bouscaren, Felton, Goodwin, Hawks, Hunt, Rea, Rodd and Wellington use ¼ inch; Mr. Myers, $\frac{5}{16}$ inch; Mr. Morison a variable radius varying inversely with the weight of sections from 0.37 to 0.19 inches, averaging about 0.27 inches; Mr. Crowell uses $\frac{1}{16}$ inch for the upper radius, and ⅛ to ¼ inch for the lower radius, the small upper radius being stated to be used for the purpose of improving the bearing of the fish-plate.

Radius of Sides of Neck.—Messrs. Morison, Myers and Wellington use straight sides, and Felton 30 inch radius; Messrs. Bouscaren, Crowell, Hawks, Hunt and Rodd use 12 inch radius; and Messrs. Goodwin and Rea, 9 inch radius.

This cannot usefully be tabulated, as the sides are not of the same form, and can best be judged of from the sections and the percentages of metal in the neck, as shown above.

In explanation of the unavoidable delay in sending out these sections and the above report, the Secretary desires to state that they were held for nearly six weeks after they were substantially complete, to enable members of the Committee to complete their sections, a delay which appeared expedient to secure completeness, as it was found that a quorum of the Committee would not be present at the annual meeting. As all the sections have been in the custody of the Secretary, he desires to state that his own sections were designed quite independently of the rest, and before he had received most of them.

Mr. J. D. Hawks, of the Committee, submits in the accompanying engraving an experiment made to test the effect of flat and thin heads. Two of the Michigan Central 80-pound rails had ½ inch planed off their tops, as shown, and were placed on sharp curves. The rail marked "No. 1" was used on the outside of an 8-degree 18-feet curve for 275 days, during which time 63 800 engines and 447 425 cars passed over it, an average of 232 engines and 1 627 cars per day. The rail marked "No. 2" was used on the inside of a 13-degree 45-feet curve for 655 days, during which time 200 430 engines and 414 615 cars passed over it, an average of 306 engines and 633 cars per day. The result upon the shape of the top was as shown.

Extremities of Base.—These with but one exception are vertical, rounded off with a very short radius at top and bottom, generally $\frac{1}{16}$ inch. The exceptions in radius are: Messrs. Hunt, Myers and Rodd use an upper radius of $\frac{1}{8}$ inch; and Mr. Myers has also a $\frac{1}{32}$ instead of $\frac{1}{16}$ inch radius at the bottom; Mr. Bouscaren has $\frac{3}{32}$ instead of $\frac{1}{16}$ inch radii. Messrs. Rea and Goodwin round the whole corner of the base.

The sections are not designed for precisely the same area of section for each nominal weight, but as this discrepancy is readily corrected, it is neglected in this summary.

Each set of sections is accompanied by a table of dimensions from which this abstract has been prepared, which it is not deemed necessary to reproduce. The explanatory communications sent in by members with their sections are subjoined hereto.

At an informal meeting of the Committee held after the annual meeting it was recommended that the Secretary prepare a set of sections averaging as nearly as might be the individual sections, neglecting any wide deviations which appear in one set of sections only. The Secretary's engagements have not permitted him to do this, but a set having the following dimensions would come very near to such an average section.

Head, 12 inches; top radius, $\frac{1}{4}$ inch; corner radius, $\frac{1}{16}$ inch; lower corner radius, vertical sides; percentage of metal, 41.5 per cent. (neglecting both the Goodwin-Rea and Rodd sections as erratic); width varying by $\frac{1}{8}$ inch for each 10 lbs., and as follows:

Weight of section in pounds	40	50	60	70	80	90	100
Width of head in inches	2.0	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$

Neck, 21 per cent. of the metal; $\frac{1}{4}$ inch top and bottom fillet radii; either straight sides or 12 inch side radius (there appears to be a division of sentiment on this point); thickness as determined by percentage and following dimensions:

Base, 37.5 per cent. of the metal; 13 degrees top angle (as also for under side of head); width same as total height of rail; vertical sides with $\frac{1}{16}$ inch top and bottom corner radii.

Total height and width of base varying by $\frac{1}{3}$ inch for each 10 pounds of section, and as follows:

Weight of section in pounds....	40	50	60	70	80	90	100
Total height and width, inches	3.67	4.0	4.33	4.67	5.0	5.33	5.67
Actual average for "	3.88	3.98	4.28	4.66	4.98	5.32	5.67

Respectfully submitted,

A. M. Wellington,

Secretary of Committee.

The following are the communications sent in by the members of the Committee in explanation of their respective designs:

Mr. G. Bouscaren writes: I send a tracing showing full-size sections for 40, 60, 80 and 100 pounds steel rails, and a tabulated statement giving the dimensions and all other elements of these sections.

The rulings taken for guidance in their preparation are:

First.—Weight of metal, 1 square inch area, 1 yard long = 10.20 pounds. To facilitate comparison we should have agreed on a modulus for the weight of steel at our last meeting. I suppose there will be some variations as to the modulus assumed by the different members of the Committee.

Second.—Height of rail and width of base equal for each section.

Third.—Curvature for top of head, sides of web, corners and fillets, the same for all sections.

Fourth.—Angle with horizontal of bottom surface of head and top surface of flange equal to 12 degrees for all sections. I think this angle should be as small as consistent with the resistance to bending and shearing in the projection of head and flange, in order that the thickness of flange at the edges be as large as possible. This is the weak point of the rail; all fractures generally start there.

Fifth.—Proportions aimed at between areas of head, web and flange:

Head..................................	45	per cent.
Web	20	"
Flange..................................	35	"
	100	"

I have not found any simple rule for interpolation of sizes between extreme sections for intermediate ones. This, however, can receive more attention later.

Mr. J. Foster Crowell encloses tracings of full-size sections of rails from 40 to 100 pounds per yard, four in all, and a tabular statement of dimensions, etc., of sections of 40, 50, 60, 70, 80, 90 and 100 pounds. He says there is a slight inconsistency in the matter of the radii of base fillets, which are given as $\frac{1}{8}$ inch for the 40 and 100 pounds, and $\frac{1}{4}$ inch for the intermediates. This is because he has considered them with reference to the strength of the rail as a beam only. If there should be mechanical difficulties in the way of such a small fillet on the larger section he thinks it would materially affect any other consideration to increase it to $\frac{1}{4}$ inch; but assumes there would be no difficulty in rolling with even less, down to $\frac{1}{16}$th-inch, and has used the latter for the head fillet.

Mr. J. D. Hawks writes: There are some features of my suggested sections herewith sent that I would strenuously insist on retaining. There are other features that I would readily consent to modify. It will be noticed that the width of head in the 90 and 100-pound sections is the same. I think it is as wide a head as could be used with safety in a Northern climate, and think so from the experience of the Michigan Central many years ago with a wide-topped rail, and the difficulty they had by reason of the wheels leaving the track in snowy weather.

I have retained the thin head that we use on the Michigan Central on our 80-pound rail for the 90 and 100-pound sections. There would be no great objection to making the head somewhat thicker for the latter sections if it was considered advisable.

Mr. George S. Morison reports a set of standards, and says: These standards are for rails varying by 5 pounds from 50 pounds per yard to 100 pounds. They are designed in accordance with regular principles which may be applied to any weight of rail, some of which principles relate to the general design of the rail, and some to the three distinctive parts. The dimensions are based on a weight of 490 pounds per cubic foot of steel.

General Design.—The rail is adapted to the form of joint in most general use, which is the angle-plate joint, and also to lay on ties in accordance with the general American practice. The height of rail is made the same as the width of base.

The distribution of metal between the three parts of the rail is fixed as follows:

Head..................................	41.5 per cent.
Web..................................	21. "
Base..................................	37.5 "

These percentages are kept constant for all weights of rail.

Head.—The head is designed in accordance with the recommendations of the Committee of the American Society of Civil Engineers on the Proper Relations to Each Other of the Sections of Railway Wheels and Rails. That is, the top is slightly curved, having a radius of 12 inches; the sides are vertical; the upper corners are rounded with a radius of ¼ inch (0.25), and the lower corners are rounded with a radius of $\frac{1}{16}$ inch (0.16). An inclination of one in four has been selected for the under sides of the head. The width between the parallel vertical sides of the head has been made 2½ inches, and is kept uniform for all weights of rail. This is a radical departure from the usual practice of rail designs, but is regarded as a very important thing. The different weights of rail are determined by the amount of business which they are expected to carry, seldom by the character of the traffic which passes over them. The same wheels run on light and on heavy rail sections. If the weight is to be carried properly down the center line of each rail, the distance between that center line and the gauge line must be kept constant. Furthermore, if the wear on wheels and rails is to approach uniformity, the wearing surface of the rails must be of uniform shape.

The amount of metal in the head is 41½ per cent. of the total metal in the rail, which makes the variation in the cross section of the head for each 5 pounds weight of rail 0.204 square inches. As the only variable in the head is the height, this variation of weight corresponds to variation of height, 0.081 inches for each 5 pounds weight of rail. The heights of head in the table given hereafter and designated as a, are calculated on this basis.

Base.—The bottom of the base of the rail is made flat. The sides of the base are two vertical parallel lines. The top of the base is made of two planes having an inclination of one in four. The sides are connected with the bottom and top surface with curves of $\frac{1}{16}$ inch (0.06) radius. The base of all weights of rails are made of similar shape. The 80-pound rail is taken as a basis to start from, the width of base for this rail being taken as 5 inches. This width corresponds to a height of base of 0.90 inches. The dimensions of the base will always be determined by the width and height, and these dimensions will vary as the square root of the weight of rail. The width of base, designated as b, and the height of base, designated as c, in the table given hereafter, are calculated in this way.

Web.—The sides of the web are made parallel. This arrangement is adopted to prevent using too thin metal for the center of the web in the lighter rails, and to prevent using too small a radius for the fillet connecting the web with the head in the heavier rails. The width of the web measured from out to out of the fillet is kept constant, and this width is fixed at 1 inch. This leaves a width of ¾ of an inch on each side under the head, for the bearing of the angle plates, which is little enough. The height of the web will always be determined by deducting from the total height of the rail (which is the same as the width of the base) the sum of the heights of the head and base. Heights of web, designated as d, given in the table below, are calculated in this way. To ascertain the thickness

of the web, the area of the web must first be calculated; from this area a small correction must be deducted to correspond to the four fillets and the triangles above and below the central height, and the remainder must be divided by the height. The correction to be made is smaller than would at first be expected, and has been taken as 0.054 square inches, which is slightly too much for the lighter rails and slightly too little for the heavier, but the error is not enough to be material. On this basis the thickness of the web, designated as *e*, given in the table hereafter, has been calculated. The radius of the fillet at top and bottom is also a variable. If the angle here was a right angle, it would be equal to one-half the difference between 1 inch and the thickness of the web. As, however, there is an inclination of one in four, the radius is 1.32 times this difference. The radii of the fillet designated as *f*, given in the table below, have been calculated on this basis.

General.—The method of determining all the variable elements in the several sections of rails having been explained, it remains only to tabulate the results. For convenience the elements have been designated by letters as follows:

Height of Head...........	*a*	Height of Web.............	*d*
Width of Base............	*b*	Thickness of Web..........	*e*
Height "	*c*	Radius of Fillet............	*f*

The table is as follows:

Weight of Rail.	Head.	Base.		Web.		
	a.	*b.*	*c.*	*d.*	*e.*	*f.*
50	1.01	3.93	0.71	2.23	0.44	0.37
55	1.09	4.15	0.75	2.31	0.47	0.35
60	1.17	4.33	0.78	2.38	0.50	0.33
65	1.26	4.51	0.81	2.44	0.53	0.31
70	1.34	4.68	0.84	2.50	0.56	0.29
75	1.42	4.84	0.87	2.55	0.58	0.28
80	1.50	5.	0.90	2.60	0.61	0.56
85	1.58	5.15	0.93	2.64	0.64	0.24
90	1.66	5.30	0.95	2.69	0.67	0.22
95	1.74	5.45	0.98	2.73	0.70	0.20
100	1.82	5.59	1.01	2.76	0.73	0.19

From this table the sections given on the accompanying sheet have been drawn.

On the first section (which is that of an 80-pound rail) all the constants are marked, these being the width of head, the width outside the fillets, and the radii of all convex curves. On the other eleven sections, which are marked with their respective weights, the veritable dimensions are marked.

Mr. E. T. D. Myers writes: My endeavor has been to base my suggestions upon the recorded recommendations of a committee of the Society, and also upon the deductions of those who have been close observers, whether as makers or users of rails. Whilst these sections do not contemplate the use of base plates, I am nevertheless one of those who believe that better methods of increasing both the bearing of the rails and their hold upon the ties, will, in the near future, come into use, and with them substantial modifications in the form of rails.

Mr. THOS. RODD writes: I send a little diagram showing approximately how the 80-pound rail would wear down on a curve. The unit strains in compression, considering the rail as a beam, non-continuous, at 20-inch bearings, are given for the original section and for the reduced section, allowing in each case 40 000 pounds as the extreme fiber strain. The little table subjoined gives the center breaking load of the original section, and of the worn section; the depth of wear being the same in each case, and as shown in each section; and the allowance being also made for side wear, as shown on the section, for curves, the extreme fiber strain being taken as 40 000 pounds. The supplemental drawing of 80-pound section shows the graduation of the strains between the outermost fibers and neutral axis, at center of span. In assuming the high extreme fiber strain of 40 000 pounds it should be borne in mind that the less strained part tends to help the more strained part; furthermore, the stresses shown exist only at midspan since they are dependent on the bending moment, which decreases from the middle towards the end of the span, and with it the intensity of the horizontal stress also, so that the strain varies not only in the vertical direction on both sides of the neutral axis, but also in the direction of the length of the rail.

ORIGINAL SECTION.		WORN SECTION.		
Weight.	Center breaking load.	Per cent. of head worn.	Center breaking load.	Per cent. of original strength remaining.
50 pounds.	43 200 pounds.	35.0	29 800 pounds.	69.0
60 "	52 700 "	33.8	38 100 "	72.3
70 "	68 300 "	31.8	51 200 "	75.0
80 "	80 800 "	30.1	60 600 "	75.0
90 "	93 600 "	32.9	78 900 "	84.3
100 "	111 400 "	28.0	98 000 "	88.0

Mr. A. M. WELLINGTON writes: The following dimensions are assumed by me as constants throughout the sections:

12 inches top radius, $\frac{1}{4}$-inch corner radius, Vertical sides, $\frac{1}{16}$-inch lower corner radius.	Pursuant to recommendations of former Committee on Form of Rails and Wheels, and for the reasons stated in their report.

1 to 4 (14 degrees 02 inches) angle of lower side of head with the horizontal, adopted instead of 13 degrees, which is perhaps more usual, for the reason that it does not sensibly diminish the efficiency of the fish-plate bearing, while fish-plates are used, and gives a slightly better form of section if fish-plates are not used. I do not consider the difference of much importance, and should be ready to assent to 13 degrees if preferred by a majority of the Committee.

Of the Neck.—$\frac{1}{4}$-inch fillet radii, as the best compromise between giving as good a fish-plate bearing as possible (requiring a short radius), and easing the transition between neck and head and base, which requires a long radius, but in my opinion not a very long one, when the neck is made fairly thick.

Vertical Sides.—In order that the thin metal furthest removed from the top and bottom masses may not cool too rapidly, the neck is made fairly thick for the same reason, and to avoid concentrating too much of the work done in rolling on the neck. If it be time, however, that the extra work done on these masses suffices to keep them hot

enough, my impression is that these sections might be improved by removing some metal from the neck and adding it to the extremities of the base.

Of the Base.—$\frac{1}{16}$-inch corner radii, Vertical sides. } The lower corner of the base should not be sharp, as it tends to promote cutting.

The upper corner should have some small rounding. There should be as much of a vertical face as possible to give bearing against spikes.

1 to 4 angle of top of base with horizontal. I adopt this partly to make it the same as the head (though there is no longer any special reason why the two should be alike).

Distribution of Metal.—I adopt for this: Head, 40 per cent.; neck, 22½ per cent.; base, 37½ per cent. I am satisfied that there is no real gain in life of rail, but rather loss, in putting more than 40 per cent. of the metal in the head; and that the neck should not be too thin. It might be well, however, to take 1 per cent. of the metal from the neck and use it to thicken the extremities of the base.

Total Height of Rail.—I assume 4 inches for a 50-pound rail, 5 inches for an 80-pound, and 6 inches for a 110-pound, as dimensions which experience favors, and by filling in the remaining heights evenly obtain the following total heights:

Wt. of rail, lbs. per yd.,	40	50	60	70	80	90	100	110
Total height, inches,	3.67	4.00	4.33	4.67	5.00	5.33	5.67	6.00

Width of Base.—I assume this as the same as the base, in accordance with current practice, up to and including 80-pound rails. Beyond that point it is not rational to design rail sections with a view to their resting directly on the tie, and if a base-plate is used it seems better to retain a constant width of 5 inches for all sections from 80 to 110 pounds inclusive. Good rolling of the heavier sections is thus promoted.

Width of Head—I believe this should be as wide as possible for all sections, and therefore that it should increase about in proportion with the height. It is desirable, on the other hand, to give some weight to the desirability of having all rail-heads of the same width. With perfectly flat rail-tops this would be quite important; with a 12-inch top radius, I believe it to be of very minor importance, for the reason that a worn tread naturally wears to about a 12-inches radius for a width considerably wider than the widest rail-head, and therefore fits well any rail-head not over 3 inches wide, on the principle of the ball and socket joint. Only in very rare instances, I believe, could the variable width cause the load to come on the corners of the rails. I therefore adopt the following widths of rail-heads:

Wt. of rail, lbs. per yd.,	40	50	60	70	80	90	100	110
Width of head, inches,	2⅛	2¼	2⅜	2½	2⅝	2¾	2⅞	3

These constants being given, and assuming the rail to require 0.98 square inches section for each 10 pounds per yard, we have the following distribution of metal in the several sections, which I extend to 110 pounds, as rails of that weight are already in use on this continent, on the Chignecto Ship Railway, and may be expected to be used elsewhere.

Sq. ins., p. c.		40 lbs.	50 lbs.	60 lbs.	70 lbs.	80 lbs.	90 lbs.	100 lbs.	110 lbs.
Head....	40	1.57	1.96	2.35	2.74	3.14	3.53	3.92	4.31
Neck....	22½	.88	1.10	1.32	1.54	1.76	1.98	2.20	2.43
Base	37½	1.47	1.84	2.21	2.58	2.94	3.31	3.68	4.04
Total...	100	3.92	4.90	5.88	6.86	7.84	8.82	9.80	10.78

Given these areas, and top slopes of 1 to 4, the center and side heights of the base are readily computed as follows: Add 0.0034 square inches to the area, to give what it would be if the corners were made sharp instead of with $\frac{1}{16}$-inch corner radii.

The base may then be divided into two parts: a rectangular base, of width w and height x, and an equilateral triangle, of width w, height $\frac{w}{8}$. We then readily obtain $x = \dfrac{A - \left(\frac{w}{4}\right)^2}{w}$, and

Total center height $h = \dfrac{A + \left(\frac{w}{4}\right)^2}{w}$

As a check, $h - x = \frac{w}{8}$.

The head may be divided by a horizontal line, tangent to the upper corner curves slightly prolonged, into two parts: (1) a very small segment of a circle of 12 inches radius, whose base (letting $w =$ the width of head in inches) is $w - 0.5$, and whose center height is h given very accurately by the formula:

$$h = \frac{\left(\frac{w - 0.5}{2}\right)^2}{24}$$

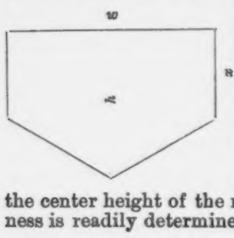
While its area is given accurately by the formula:

$$A = \left(w - 0.5\right) \times \frac{2}{3} h.$$

In this way the center height and area added by the use of a 12-inch top radius, instead of a flat-top, is found to be as follows:

	40 lbs.	50 lbs.	60 lbs.	70 lbs.	80 lbs.	90 lbs.	100 lbs.	110 lbs.
Center height, inches...	0.027	0.032	0.037	0.042	0.047	0.053	0.059	0.065
Area, square inches......	0.003	0.005	0.015	0.024	0.034	0.047	0.060	0.076

Deducting this small area from the total allotted to the head, and on the other hand adding to it the small quantity (0.032 square inches) which would be required to fill out the rounded corners to square corners, and we obtain an area of the same general form as the base, as shown in sketch, the width and total area of which are known, from which h and x (if desired) are readily computed. Adding to h the center height of the crowning, as already determined, we obtain the total center height of the head, as shown on sections.



The total height of the rail, less the determined center heights of base and head, gives the center height of the neck, from which and its known area the thickness is readily determined.

ERRATA.

Page 3. 4th line of paragraph beginning "WIDTH OF BASE," for "sections" read "exceptions."

Page 4, 1st line, for "interest" read "intent."

Page 5. table, strike out the references to maximum and minimum.

Page 5, 3d paragraph from bottom. Precede it by the words "*Thickness of Neck.*—"

Page 5, last paragraph, for "8-degree 18-feet" read "8-degree 18-minutes," and for "13-degree 45-feet" read "13-degree 45 minute."

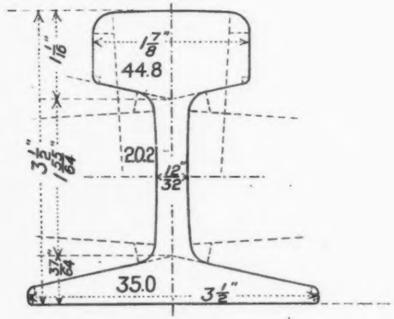
Page 10, 1st line of 3d paragraph from bottom, for "14 degrees 02 inches" read "14-degrees 02-minutes."

Page 10, 4th line from bottom, insert a period for the comma after "rapidly."

Plate I. The percentages on the sections of A. M. Wellington should read 40, 22½ and 37½, instead of 40, 22 and 38.

G. BOUSCAREN. | J. FOSTER CROWELL. | S. M. FELTON, JR.

40-LB.



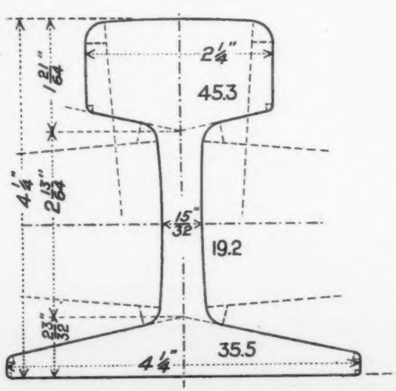
50-LB.

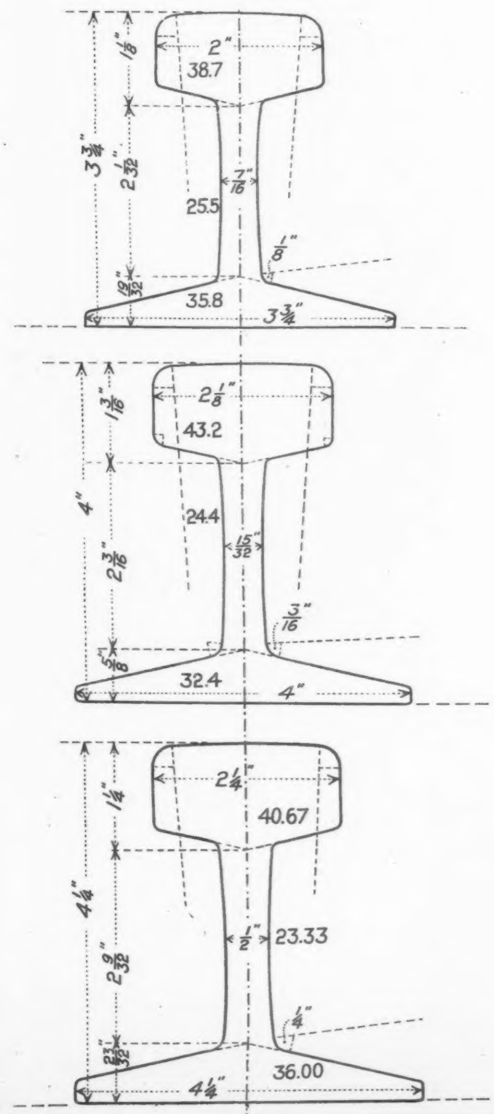
COMMITTEE ON STANDARD RAIL SECTIONS.

G. BOUSCAREN, CHAIRMAN.

VIRGIL G. BOGUE.	GEO. S. MORISON.
J. FOSTER CROWELL.	E. D. T. MYERS.
S. M. FELTON, JR.	SAMUEL REA.
H. STANLEY GOODWIN.	THOS. RODD.
J. D. HAWKS.	F. M. WILDER.
R. W. HUNT.	A. M. WELLINGTON

60-LB.





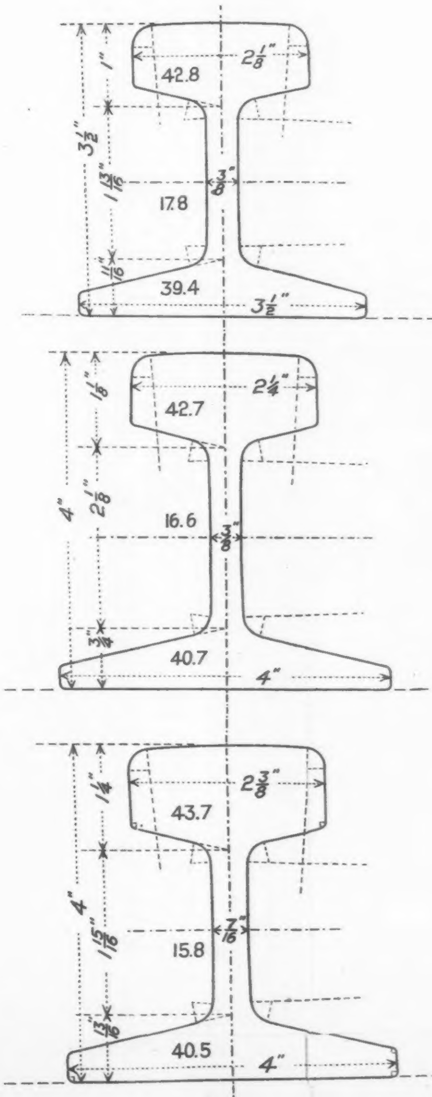


PLATE I.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXIV. NO. 461.
REPORT ON
STANDARD RAIL SECTIONS.

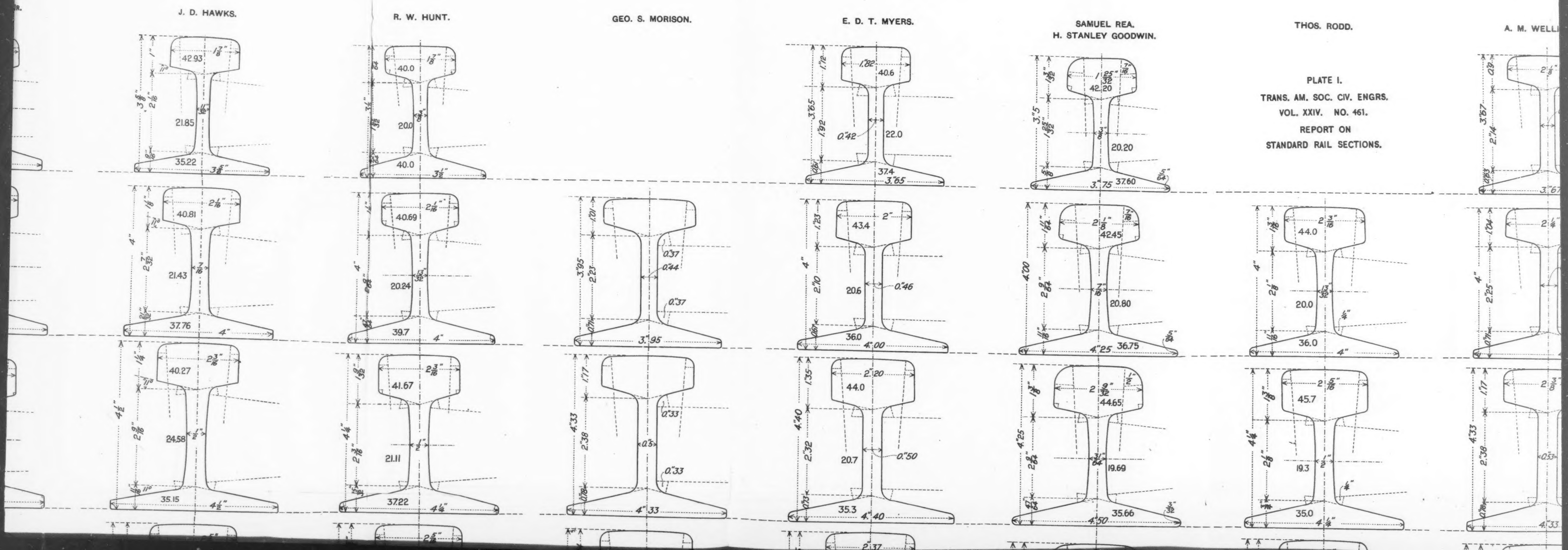


PLATE I.

TRANS. AM. SOC. CIV. ENGRS.

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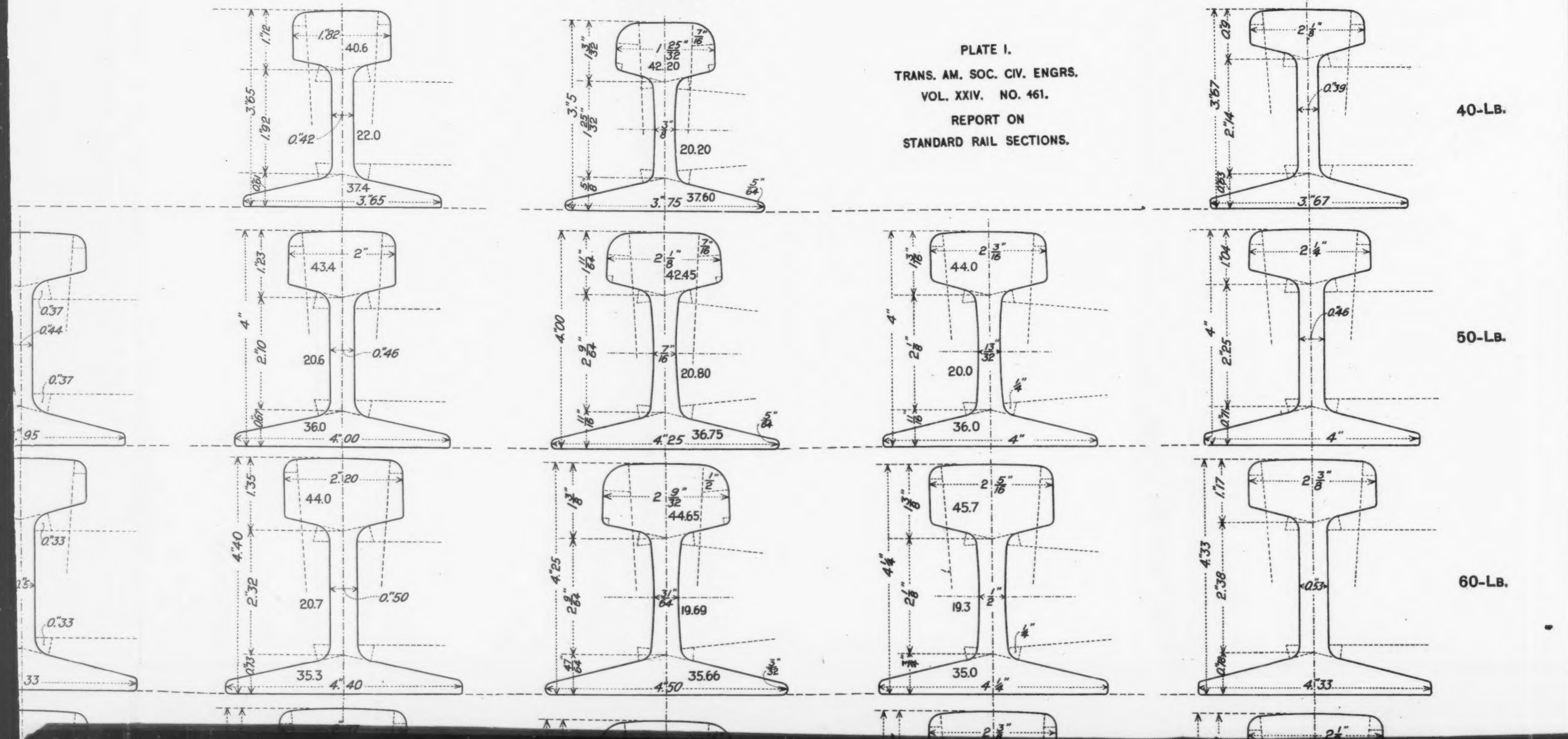
STANDARD RAIL SECTIONS.

. MORISON. | E. D. T. MYERS. | SAMUEL REA. H. STANLEY GOODWIN. | THOS. RODD. | A. M. WELLINGTON.

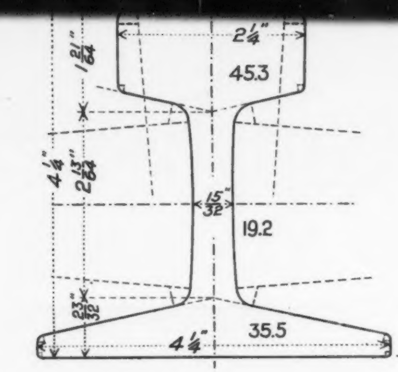


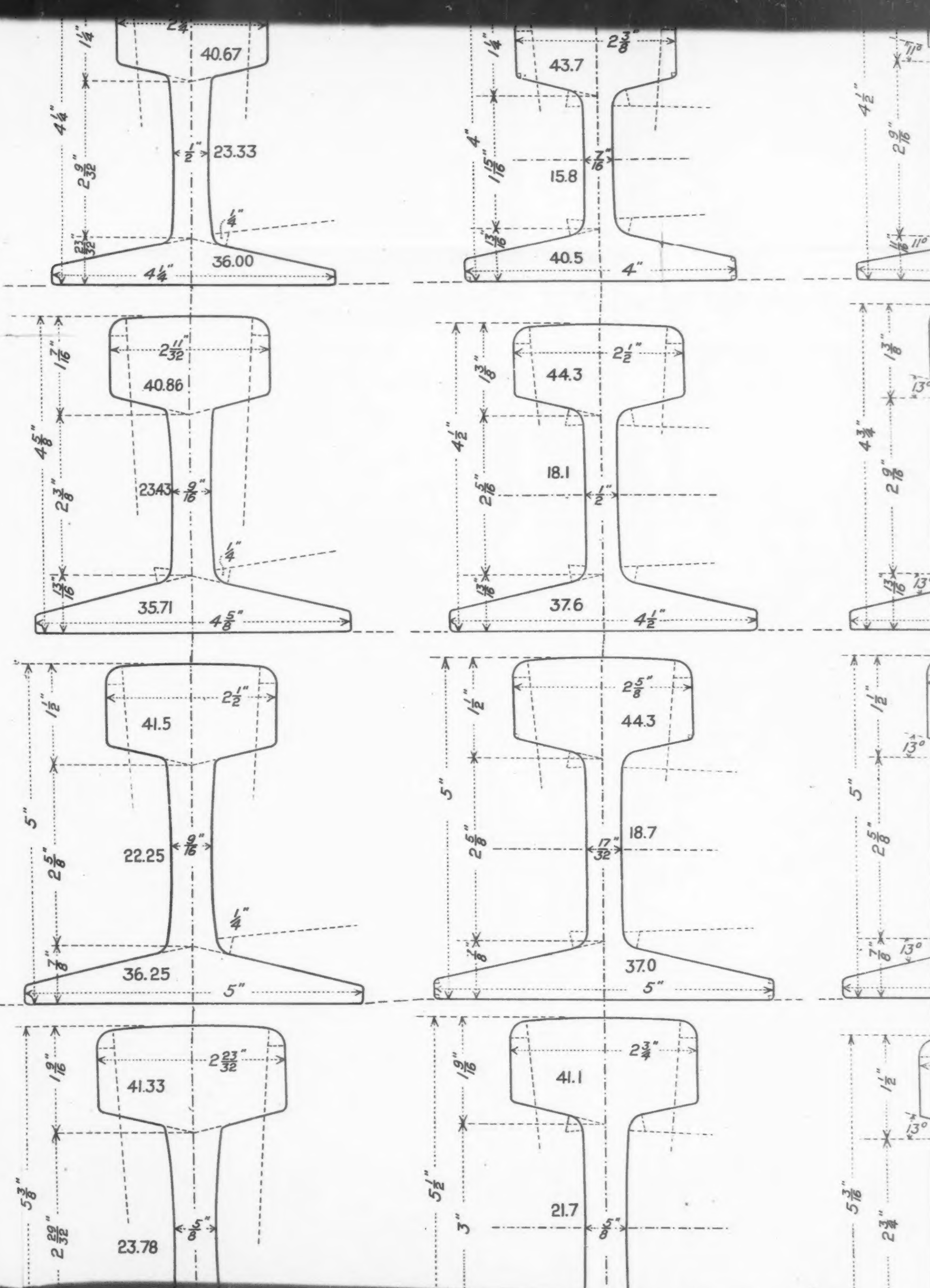
40-LB.

50-LB.

60-LB.

60-LB.

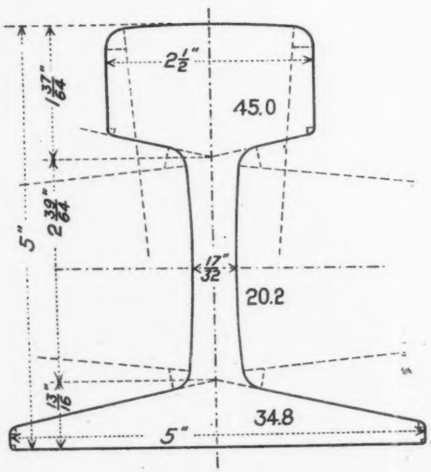




EXPLANATORY NOTE.—The several designs for sections of any one given weight are in horizontal rows; the several designs by each member of the Committee in vertical columns.

The dimensions which are common to the sections of all weights in each set of sections are shown on the 100-lb. section only. The dimensions which are not common to all sections are the only ones shown on the sections lighter than 100 lbs.

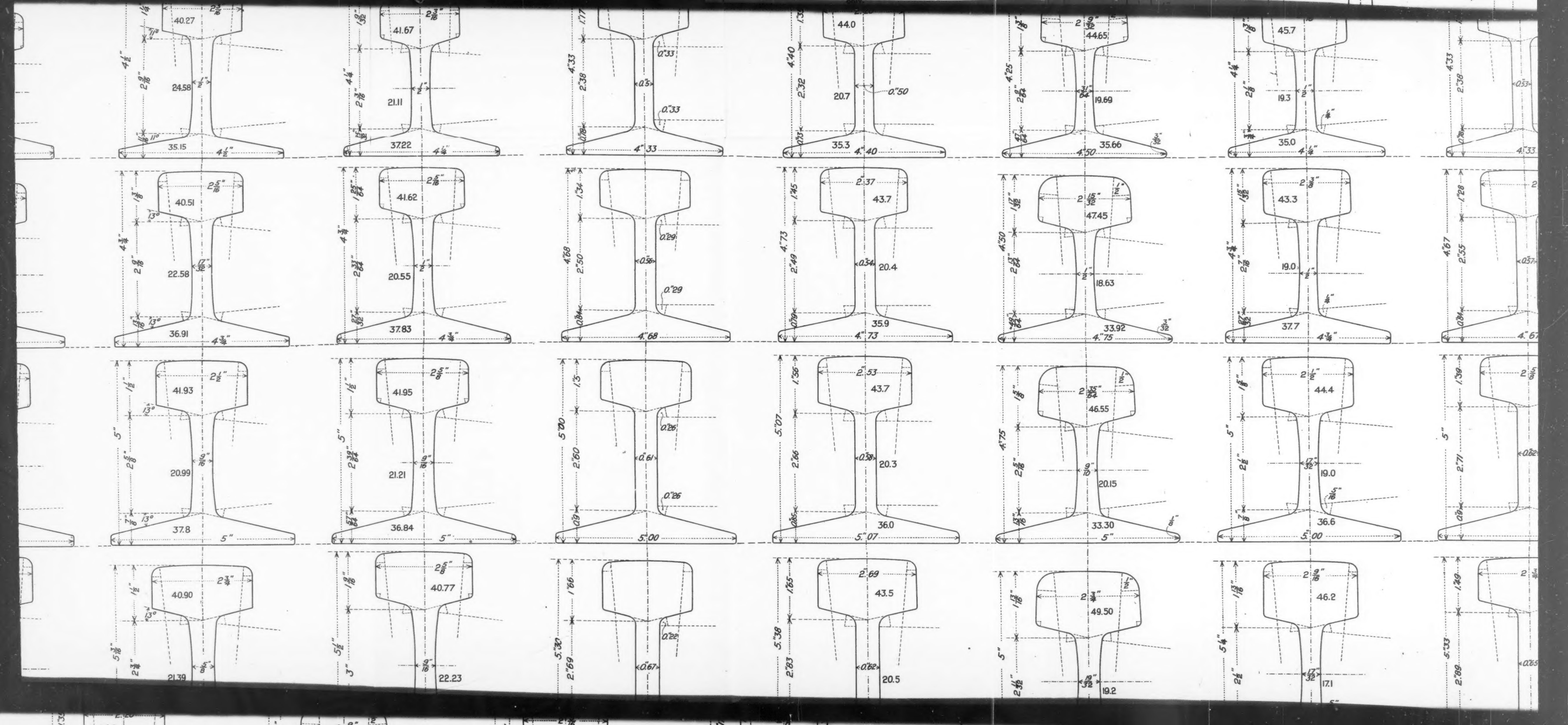
70-LB.

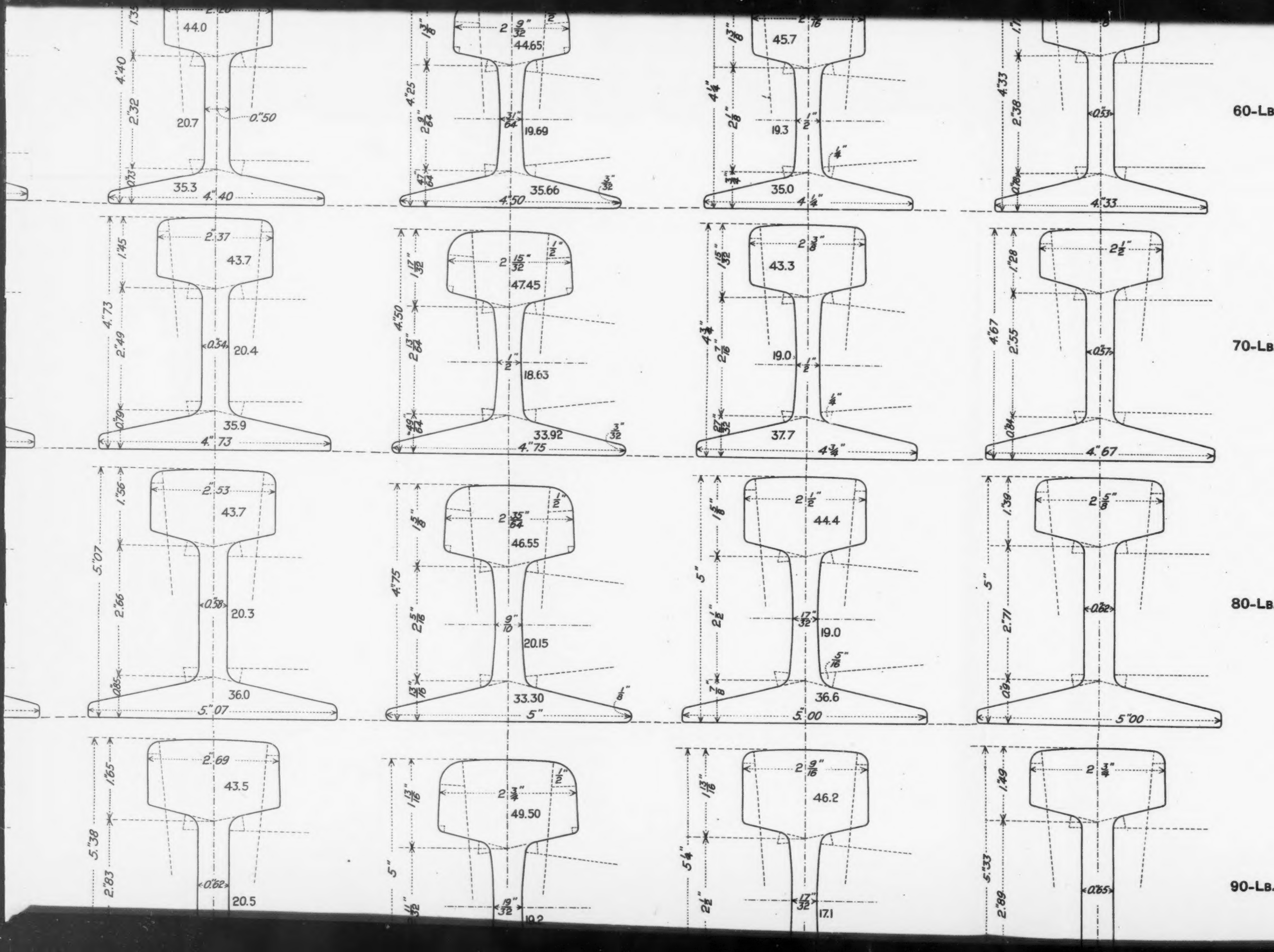


80-LB.

The percentage of metal in head, neck and base is shown by upright figures on each section, except in the two sets of sections (Messrs. Morison's and Wellington's), which make these percentages uniform throughout. The latter have the percentages given on the 100-lb. sections only.

90-LB.




44.0
20.7
0."50
35.3
4."40
44.65
19.69
35.66
4."50
45.7
19.3
35.0
60-Lb.
2."37
43.7
20.4
35.9
4."73
47.45
18.63
33.92
4."75
43.3
19.0
37.7
70-Lb.
2."53
43.7
20.3
36.0
5."07
46.55
20.15
33.30
5"
44.4
19.0
36.6
5."00
80-Lb.
2."69
43.5
20.5
49.50
19.2
46.2
17.1
90-Lb.

G. BOUSCAREN. J. FOSTER CROWELL. S. M. FELTON, JR. J. D

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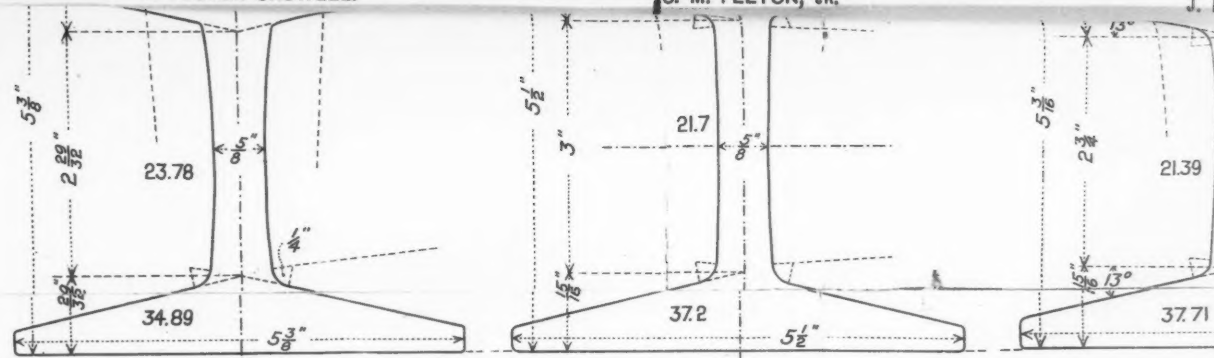
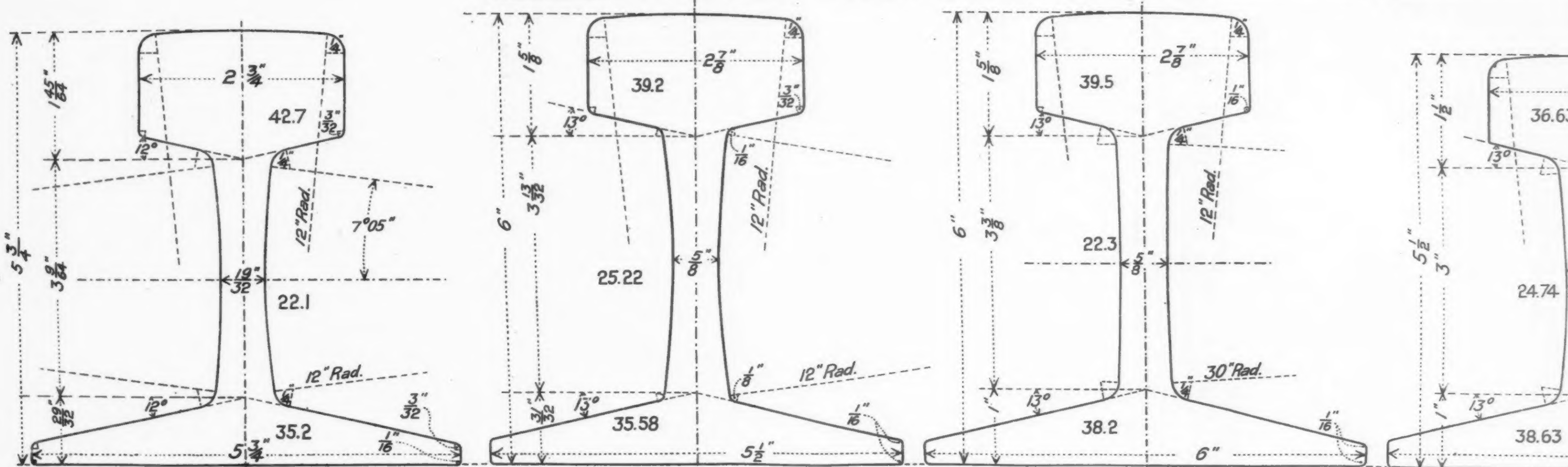
90-LB.



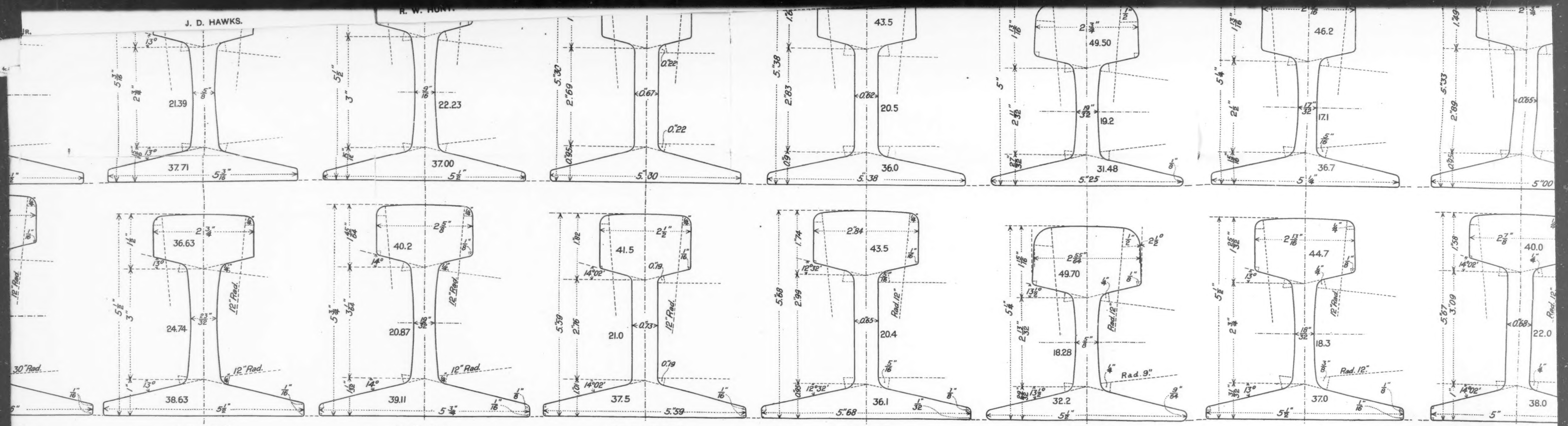
100-LB.



G. BOUSCAREN. J. FOSTER CROWELL. S. M. FELTON, JR. J. D.

PRELIMINARY DESIGNS BY THE INDIVIDUAL MEMBER

PREPARED UNDER RESOLUTION C

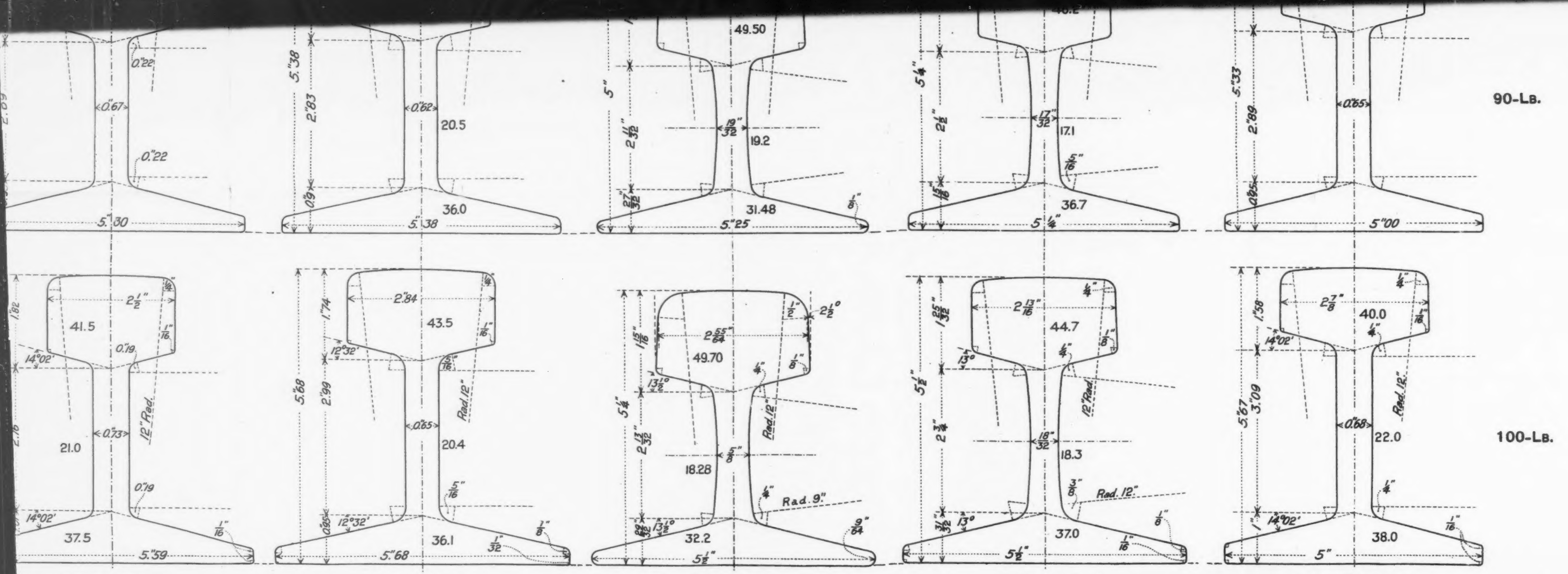


JR. J. D. HAWKS. R. W. HUNT. GEO. S. MORISON. E. D. T. MYERS. SAMUEL REA. H. STANLEY GOODWIN. THOS. RODD. A. M. WELLINGTON

THE INDIVIDUAL MEMBERS OF THE AM. SOC. C. E. COMMITTEE ON STANDARD RAIL SECTIONS, SHOWING SECTIONS VARYING FROM 40 LBS. TO 100 LBS. PER YARD.

PREPARED UNDER RESOLUTION OF THE COMMITTEE AS AN EXPRESSION OF THE INDIVIDUAL PREFERENCE OF THE SEVERAL MEMBERS PRIOR TO ANY DISCUSSION IN COMMITTEE.

CHAS. HART & SONS, LITH.



GEO. S. MCRISON. E. D. T. MYERS. SAMUEL REA. H. STANLEY GOODWIN. THOS. RODD. A. M. WELLINGTON.

DARD RAIL SECTIONS, SHOWING SECTIONS VARYING FROM 40 LBS. TO 100 LBS. PER YARD.

ERENCE OF THE SEVERAL MEMBERS PRIOR TO ANY DISCUSSION IN COMMITTEE.

CHAS. HART & SONS, LITH., 36 VESEY ST., N.Y.

PLATE II.
TRANS. AM. SOC. C. E.
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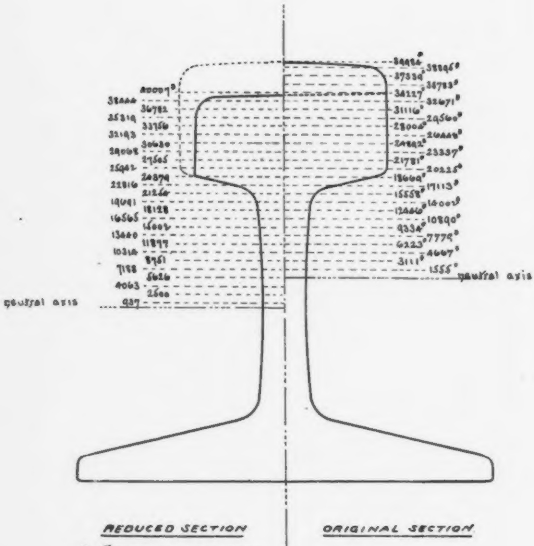

REDUCED SECTION

30.1% OF ORIGINAL HEAD WORN

ORIGINAL SECTION

80 LB SECTION